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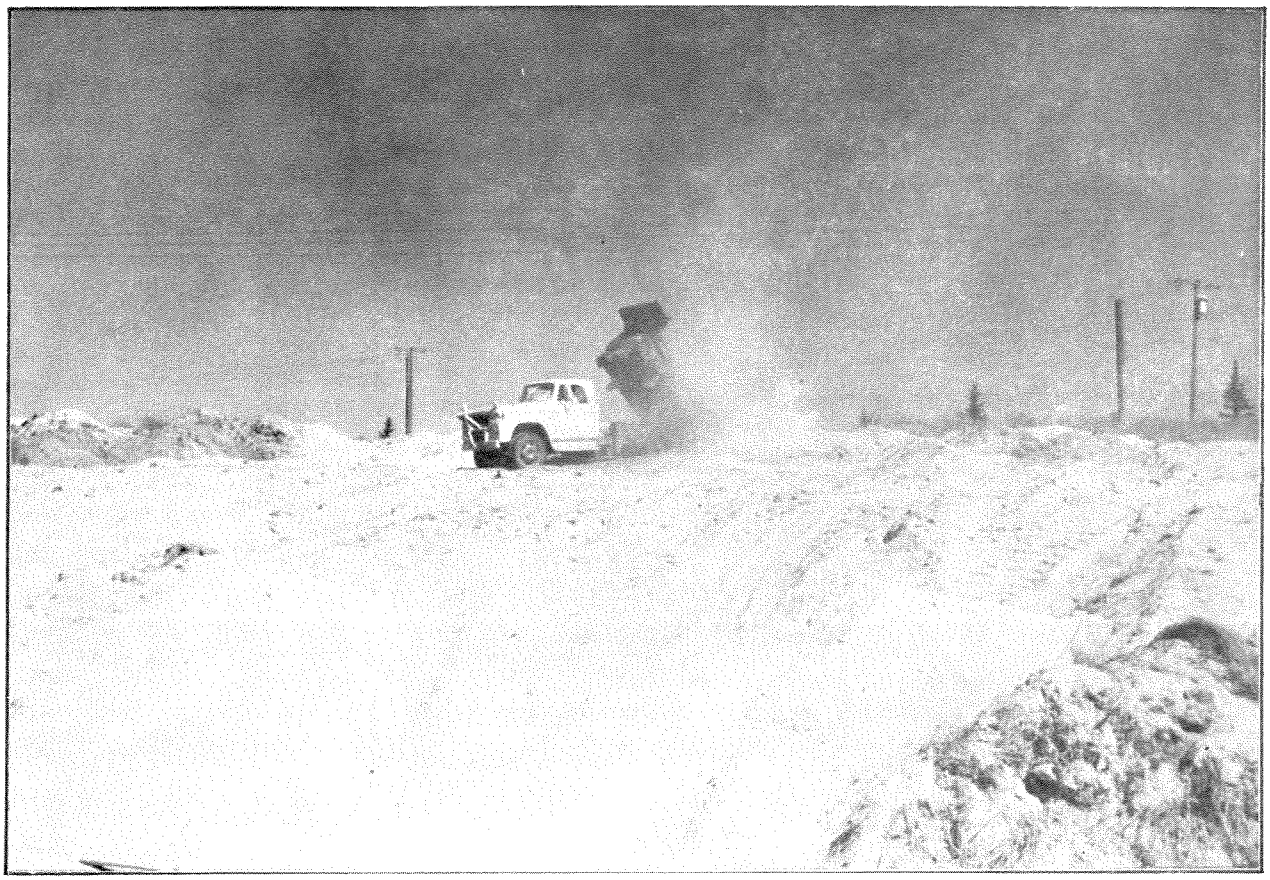
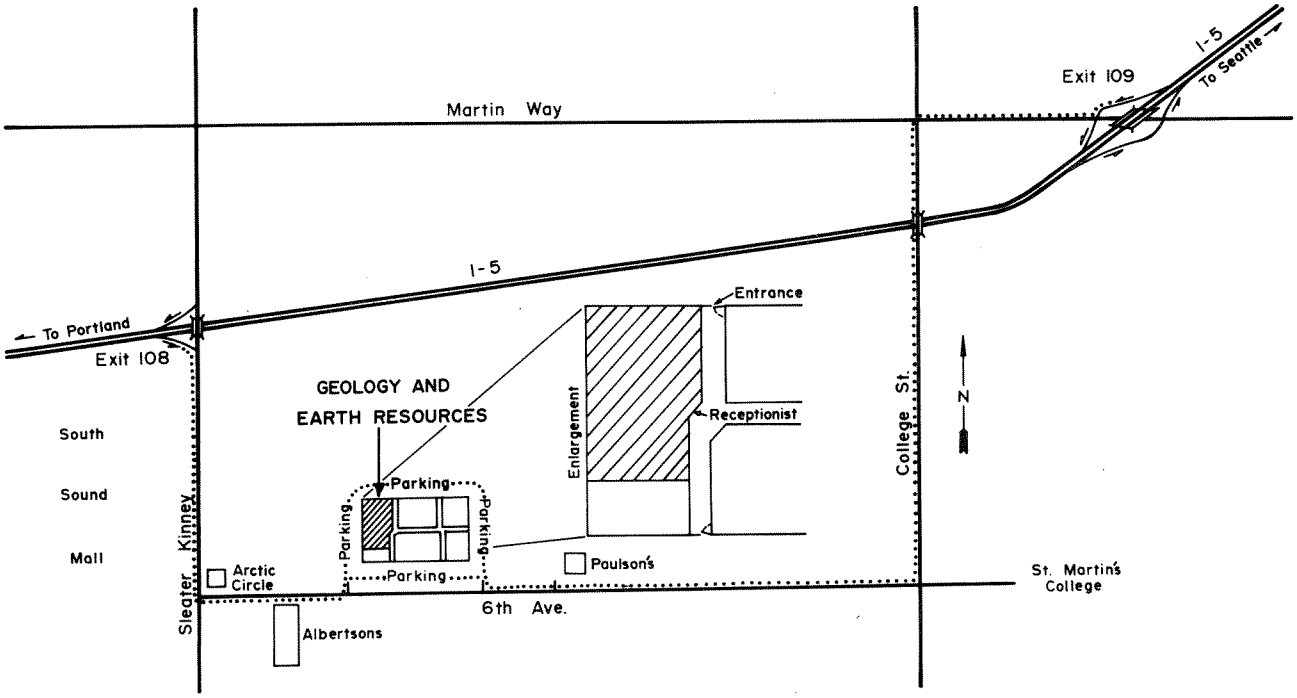


St. Helens ash cleanup in Ritzville. Dumpsite contains 90,000 cubic yards of ash.

BERT L. COLE
COMMISSIONER OF PUBLIC LANDS

RALPH A. BESWICK, Supervisor
DEPARTMENT OF NATURAL RESOURCES

VAUGHN E. LIVINGSTON, JR., State Geologist
DIVISION OF GEOLOGY AND EARTH RESOURCES



Mailing address: Department of Natural Resources
Division of Geology and Earth Resources
Olympia, WA 98504
(206) 753-6183

Division Manager

Vaughn E. (Ted) Livingston, Jr.

Assistant Division Managers

Donald M. Ford and J. Eric Schuster

Geologists

Bonnie Bunning	Josh Logan	Wayne S. Moen	James G. Rigby	Ellis R. Vonheeder
Allen J. Fiksdal	Carl R. McFarland	William Phillips	Keith Stoffel	Timothy J. Walsh
Mike Korosec	Glennda B. McLucas	Weldon W. Rau	Gerald W. Thorsen	

Librarian	Secretaries	Laboratory	Cartographers	Publications
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The Washington Geologic Newsletter, a quarterly report of geologic articles, is published by the Division of Geology and Earth Resources, Department of Natural Resources. The newsletter is free upon request.

The division also publishes bulletins, information circulars, and geologic maps. A list of these publications will be sent upon request.

CLEANUP AND DISPOSAL OF MOUNT ST. HELENS ASH IN EASTERN WASHINGTON

By Glennda B. McLucas

The May 18, 1980, eruption of Mount St. Helens covered 50 percent of Washington State with volcanic ash. While 19 of the 39 counties in the state were covered to some extent by ash, five eastern Washington counties received the bulk of the largest ash fall. Of the 0.58 to 0.77 cubic mile (1.5 to 2.0 km^3) of ash that fell during the main May 18th eruptive event (Hammond, 1980[1/]), 0.23 cubic mile or 1,268 million cubic yards fell in Adams, Grant, Spokane, Whitman, and Yakima Counties. Figure 1 shows the ash fall distribution in Washington State.

Each county and its major municipalities dealt with cleanup and disposal of the ash in different ways according to their individual priorities, degree of devastation, financial and equipment capabilities, and managerial methods.

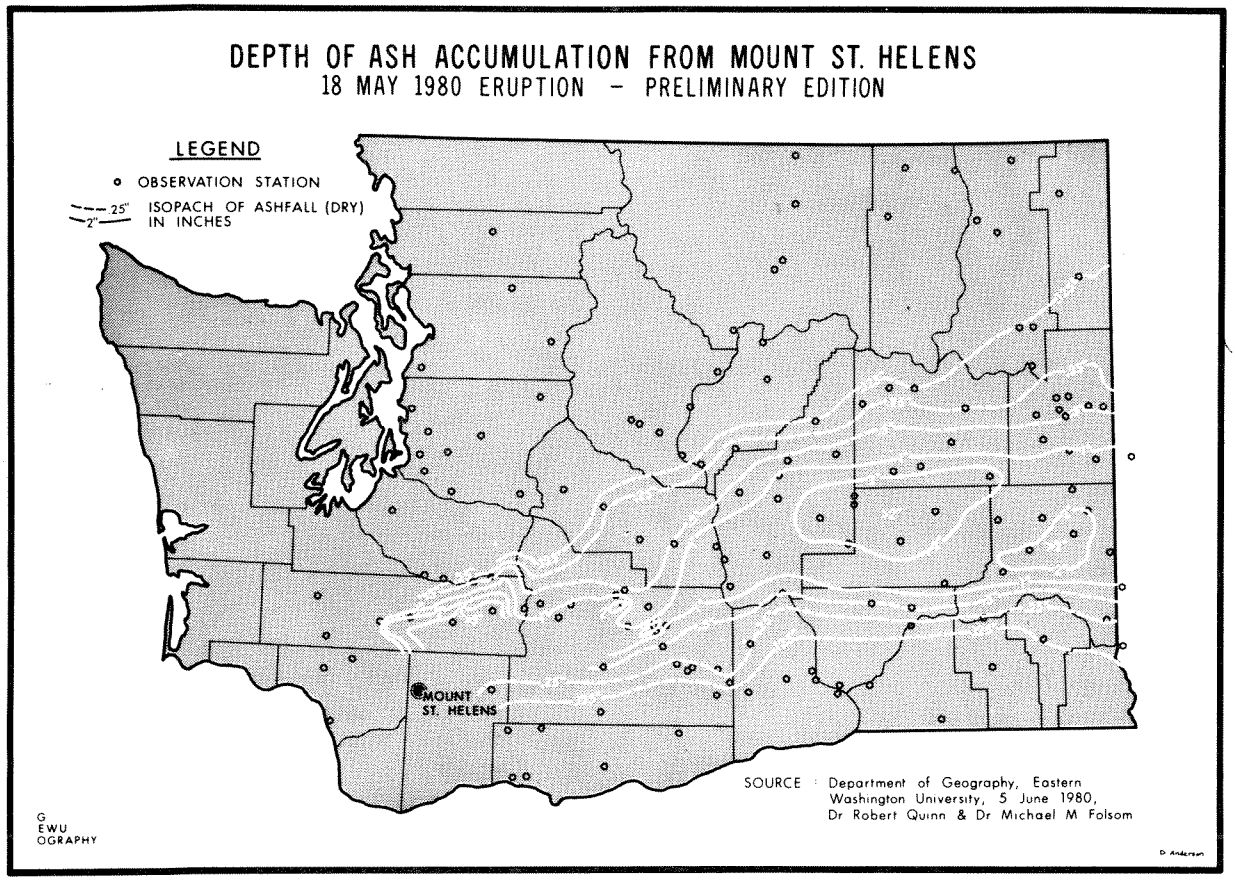


FIGURE 1

[1/] Hammond, P. E., 1980, Mount St. Helens: AEG Newsletter, v. 23, no. 3, p. 12-24.

This report discusses how each county and its major municipality(s) dealt with the ash fall disaster of May 18th.

Adams County

Adams County received 0.084 cubic mile or 458 million cubic yards of ash. One hundred percent of the county was covered with ash to various depths; 3 to 5 inches in the northern two-thirds of the county and 1 to 2 inches in the southern one-third. The Adams County Department of Public Works is responsible for 1,800 miles of roads, of which 550 miles are paved and 1,250 miles are gravel. Ash along roads was bladed into ditches where they existed; where they did not, ash was bladed directly into fallow fields to be plowed under at the next cultivation. Where standing crops bordered the road, ash was bladed into rows adjacent to fields to be plowed under following harvest. At present, the county has not initiated removal of ash from ditches. Where property owners consented, small amounts of ash were dumped in private landfills.

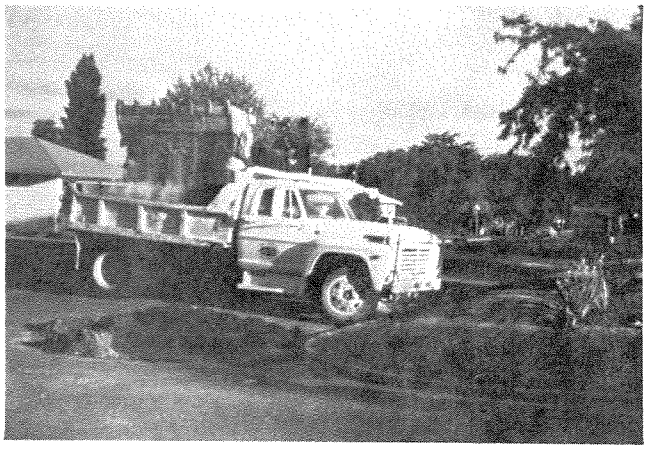
On its 1,250 miles of gravel roads, the county plans to spread 1½ inches of loose gravel to replace that lost during blading. About 400,000 yards of gravel are needed to complete this task. In a normal year, the county crushes 90,000 yards from local basalt and gravel pits for resurfacing purposes. On the 550 miles of paved roads, the county bladed and broomed the ash into ditches, keeping dust to a minimum by first spraying the road with water.

As a dust palliative, the county has sprayed some roads and shoulders with lignin sulfonate, a byproduct of the pulp industry. It requires two applications at $98 per ton. As with other dust-abatement compounds, it is somewhat water soluble and doesn't hold up well under road blading.

According to the Adams County Director of Public Works, Gary Miller, the ash has been instrumental in the breakup of gravel roads several weeks ahead of the breakup associated with heavy harvest traffic. Because of its high degree of abrasiveness, the ash breaks down the soil component which leads to chuckholes and washouts. Undoubtedly the removal of the surface gravel during blading was also a major factor in the early breakup of roadbeds.

The county's total estimated cleanup costs are $4½ million, $300,000 of which was spent in the first 4 weeks. The normal annual budget is $1.3 million.

Othello, the largest city in Adams County, had an average depth of 7/8th of an inch of ash over 1,040 city acres (134,230 cubic yards). Ash was bladed and broomed from 28 miles of paved roads and disposed of in private pits and landfills, as well as in an abandoned municipal garbage dump. All sites will be covered with topsoil to prevent redistribution by the wind.



Front-end loader fills city dumptruck in final days of street cleanup at 3rd and Spruce, Othello. Photo courtesy of Wade Stevenson, Othello.

The city is studying the possibility of using ash to coat the bottoms and sides of municipal sewer settling ponds. The existing 25 acres of lagoon are presently lined with

A burrowing animal cleaning ash from his home. Taken along Old Milwaukee Road Yard north of Othello by Wade Stevenson, Othello.

This 2-acre site in Ritzville, normally reserved for surplus snow, contains 13,000 cubic yards of ash.

bentonite, imported from outside the area at considerable expense. When the May 18th ash fall created a local supply, the engineering firm responsible for the design and construction of the sewer lagoons (Brown and Caldwell, Engineers, Seattle) considered the use of ash as a partial substitute for bentonite in the 50 acres of sewer lagoon the city plans to construct. Othello did not stockpile any of its ash, however, so that ash would have to be imported from Moses Lake. The resulting transportation costs and the high degree of contamination in the ash will probably prevent its use in the settling ponds.

Ritzville, the second largest city in Adams County, was covered with 4 inches of ash throughout its 700 acres (372,680 cubic yards). The city bladed and broomed its streets and hauled the ash to two disposal sites within city limits. Initially ash was dumped in an area adjacent to the airport that is normally reserved for snow. The deposit, largely free of contaminants, is 4 feet deep over approximately 3 acres of ground (13,000 cubic yards). It has not been covered or coated with a dust palliative so that the site presents a dust problem.

As a permanent dumpsite the city chose an abandoned basalt quarry on the western edge of town. The quarry involves 2 to 3 acres, up to 30 feet in depth, and is approximately two-thirds full. Estimates by city officials of the amount of ash stockpiled in this pit are 90,000 cubic yards. The material in the quarry is dirty, contaminated with everything from sod to rubber tires. Ritzville officials plan to transport the ash from the airport dumpsite to the quarry site, then cap it with topsoil and grass at a cost of $25,000. The estimated cleanup cost in Ritzville is a total of $0.5 million, $227,000 of which was incurred by June 20th. By applying the total ash cleanup cost to the 210,000 tons of ash stockpiled in Ritzville, the price per ton is $2.37.

Grant County

Two-thirds of Grant County was covered by ash including all of the area south of Soap Lake (see fig. 1). The average depth was 1 to 2 inches for a total of 0.048 cubic miles or 261 million cubic yards. Grant County has

2,400 miles of roads, 1,200 miles of which are paved and 1,200 miles graveled. Ash fell on 2,000 of the 2,400 miles of road, from a trace to 2½ inches in depth. Around 780 miles of gravel road and 560 miles of paved road were covered with a minimum of 3/4th of an inch of ash. Paved roads were bladed and flushed with water. Gravel roads were graded with resulting removal of most surface gravel. The county plans to regravel 220 miles of their unpaved roads. So far they have put down 1½ inches of gravel on 145 miles of road and plan to regravel 75 miles more. Material is being supplied by gravel pits in the area, seven of which have been depleted since May 18th.

Ash stabilization along and adjacent to roads is being accomplished with the use of rock salt. Salt draws moisture from the air so that the associated ash also absorbs moisture and becomes more stable. The salt also creates an ionic bond with associated soil and ash which increases its stabilization properties. To date, 25 miles of road have been treated with salt, with plans to salt another 100 miles.

In small residential areas the county used trucks and loaders to remove the ash. They have stockpiled 50,000 cubic yards of ash at 20 landfill sites throughout the county. At present they have no plans to stabilize the ash piles.

Moses Lake, the largest city in Grant County, was covered to an average depth of 3½ inches of ash throughout its 3.5 square miles (1,084,160 cubic yards). Robert West, assistant city manager, estimates a total ash fall of 2½ million tons, 1-3/4 million tons of which is stockpiled in vacant lots all over town.

The ash was removed from buildings, grounds, and 60 miles of paved roads. Altogether Moses Lake has 10 or more substantial ash dumpsites in addition to small piles in several vacant lots. Initially the city dumped the ash in a wetlands area south of the city and within a few blocks of Moses Lake. The area involves 1 to 2 acres, up to 4 feet in depth (9,680 cubic yards). This disposal site became very controversial in regard to its potential hazard to the wetland environment and the site was quickly closed to dumping by the Washington State Department of Ecology.

The largest dumpsite is in the northeastern part of town and involves 10 acres, 5 feet in depth (80,670 cubic yards). Another large stockpile, adjacent to a water tower on the south side of town, covers more than 5 acres to an average depth of 4 feet (32,270 cubic yards). None of the dumpsites have been covered and all are contaminated with extraneous material. The city plans to level and cover all sites with 1 inch of topsoil. The city estimates a total cleanup cost of $2½ million. If this cost is applied to the 263,000 tons of ash stockpiled in Moses Lake, the price per ton is $9.50.

Ash dumpsite in wetlands near Moses Lake. Ten thousand cubic yards of ash were dumped at this controversial site before the Washington Department of Ecology requested closure.

Spokane County

Spokane County was covered to various depths by the ash with a total of 0.033 cubic mile or 180 million cubic yards. North of the city of Spokane only trace amounts were recorded; south of Spokane, however, an average of 2½ inches accumulated. In Spokane proper, ½ to 3/4 of an inch fell. See figure 1 for ash distribution.

The county has 2,885 miles of roads, 1,500 miles paved and 1,385 miles graveled. To some degree all roads were affected by the ash; however, north of Spokane the light dusting did not warrant attention. Paved roads were cleaned by using flushing and sweeping equipment in conjunction with wet sawdust. On gravel roads with 1 inch or less ash, it was bladed into the road to mix with surface material. On gravel roads with greater than 1 inch of ash, it was bladed into ditches and hauled away. The county is regraveling roads in front of residences and at intersections with 1 inch of gravel. About 400 miles of roadway will ultimately require regraveling. Spokane County does not have a central ash dumpsite. They have hauled the ash to landfills and abandoned gravel pits in rural areas.

Spokane County is evaluating the use of a 32 percent calcium chloride solution as a dust palliative. Calcium chloride penetrates the ash while water and oil remain on the surface in puddles. The calcium chloride solution therefore stabilizes the ash and it stands up to blading; winter moisture may leach it out, however. The county has applied the solution to a 1-mile test strip.

The city of Spokane hauled its ash to two large municipal landfills, one on the south end of town and another on the northeast side. It is impossible to estimate the total number of cubic yards involved in these sites because new ash is being added daily from a variety of sources, along with normal refuse. All material is being covered daily. These conditions of disposal in conjunction with the sawdust that was added to the ash during street cleaning makes recovery of ash from Spokane impossible.

Bags of ash in front of Spokane city hall waiting for removal. Photo courtesy of Wade Stevenson, Othello.

Ash entered Spokane's sewer system to such levels that 4 crews and vacuum trucks are working full-time to clean out the 13,700 catch basins involved. Two sewage treatment plants also received ash. The first is two-

Vacuum truck sucking ash from Spokane city sewer catch basin. Photo courtesy of Wade Stevenson, Othello.

thirds full and the second is one-third full. They are being cleaned with clamshell equipment. Sewage treatment personnel discovered that when the ash effluent was kept flowing through the system, biological processes were destroyed. If the ash was allowed to settle out, however, organic material flocculated and adhered to the ash, then settled to the bottom of the tanks along with it. As a result, the biological oxygen demand (BOD) of the effluent was at an all-time low, much lower than state licensing requirements.

Spokane's total cleanup costs totaled $2,100,000, $389,999 of which was spent on face masks for local residents.

Whitman County

Whitman County was covered to varying depths by ash, from trace amounts at Clarkston in the extreme southeast corner to 3 inches in the extreme northwest corner. A total of 310 million cubic yards fell within county boundaries.

The county has 2,000 miles of road, 800 miles paved and 1,200 miles gravel. Of these 2,000 miles of road, 1,100 miles were covered with an average of 1½ inches of ash. County public works crews bladed and washed the roads twice. In the process they removed 1 inch of surface gravel from the unpaved roads. County Engineer Marvin Carroll estimates a required 400,000 cubic yards of gravel to resurface unpaved roads. To date 50 miles have been resurfaced. At the time of the ash fall, Whitman County had a 100,000 cubic yard gravel stockpile which was estimated to be a 5-year supply. That pile is now depleted; it will be restored when road resurfacing is complete, however. An estimated 90 percent of the county will be resurfaced with crushed basalt.

The county did very little investigation of dust abatement techniques. State highway department personnel performed a dust abatement test involving lignin sulphonate on the shoulder of a state road in the county. At that time, the county decided that no palliative would hold up on gravel roads and abandoned any thought of using them.

When ash was removed from county roads, it was mixed in with gravel and native soil. The county is having problems obtaining permission from farmers in the area to dump this totally unproductive mixture on their land. As a result, the county is incurring additional mileage costs associated with hauling the material to scabland tracts several miles out of the way.

Total cleanup costs for the county are estimated at $3 to $4 million, $½ million of which has been incurred to date.

Pullman, the largest city in Whitman County, was covered with ½ inch of ash. The city cleaned its streets by enlisting the aid of local residents. Home owners scraped the ash from mid-street to the curbs and then wet the ash down. City crews then removed the ash with front-end loaders and dumptrucks. No central dumpsite was established; several small landfills were established instead.

Much of the ash in Pullman was washed into storm sewers. Four inches of rainfall within 30 days of the ash fall, combined with Pullman's hilly topography, kept the sewers flushed out so that no problems were encountered with sewer blockage. Pullman's cleanup cost was $77,000.

Colfax, Whitman County's second largest municipality, has incurred $107,000 in cleanup costs to date, $35,000 of which was spent in removal of ash from storm sewers. The city bladed and washed its streets, then hauled the ash to three dumpsites which have been covered with topsoil. The largest pile holds approximately 6,000 cubic yards of ash.

Yakima County

Only the northern two-thirds of Yakima County was covered with ash (see fig. 1), for a total of 59 million cubic yards. The ash was much coarser and heavier than the ash that fell on more easterly counties. Around 777 miles of county road were covered to a uniform depth of ½ inch.

Ash removal was accomplished by blading and brushing in combination with water flushing. Louis Haff, county engineer, found that the ash would absorb 30 percent of its weight in water before it would become sufficiently fluid to flow. The county dumped all ash on small landfill sites on private rural property and considers these sites final. These small piles are a nuisance because the wind is constantly redistributing the ash.

The city of Yakima has stockpiled its ash on three major sites and several small sites throughout the city. The largest site, on the northwest edge of town, involves 3 to 4 acres up to 15 feet in depth, and holds about 90,000 cubic yards of ash. The city installed an extensive underground sprinkling system in the landfill at a cost of $35,000. The site was then covered with 2 inches of topsoil, seeded to grass, and converted to a city park (Chesterly Park). The second site is at the Yakima County fairgrounds where the ash was used to build up an infield. The county dumped 30,000 to 40,000 cubic yards of ash on this site, covered it with topsoil, and seeded it to grass.

Yakima municipal ash landfill, now Chesterly Park. Site represents 5 acres, up to 15 feet in depth (90,000 cubic yards), including a $35,000 underground sprinkler system.

The third site is 2 blocks north of the airport and involves 15,000 to 20,000 cubic yards of ash. Because the landowner has changed his mind about the desirability of the landfill, the city of Yakima may have to relocate it.

Initially a great deal of ash was flushed into Yakima's sewer system, and ultimately its municipal sewage treatment plant. At the end of the third day, the treatment plant was bypassed and the ash-laden sewage was dumped directly into the Yakima River. The reason for the bypass was that the ash hopelessly clogged the plant, totally disrupting most of its mechanical and biological processes. The cost for restoration of the treatment plant to full use is estimated at between $2 and $4 million. Yakima's total ash cleanup cost, above that for the treatment plant, is $2 million.

NORTHWEST MINING ASSOCIATION PLANS ANNUAL CONVENTION

Keith J. Droste, general manager of Day Mines, Inc., has been named chairman of the Northwest Mining Association 86th annual convention scheduled for December 4-6 in Spokane, Washington.

"Speakers at the convention sessions will discuss the need to look forward to opportunities as well as examine problems facing the mineral industry and nation. Experts from throughout

the industry will share their knowledge of new exploration and mining techniques," said Droste. Recent mineral discoveries, energy sources and supplies, regulatory legislation, environmental planning, and metal markets also will be discussed

Convention details and registration materials are available from the Northwest Mining Association, 1020 Riverside Ave., Spokane, WA 99201.

U.S. GEOLOGICAL SURVEY CURRENT ACTIVITIES IN WASHINGTON, 1980

MINERAL RESOURCES ACTIVITIES

Glacier Peak Wilderness and proposed additions, Washington, Arthur B. Ford. Geologic mapping and geochemical sampling will be conducted in the northern and western parts of the study area.

Mineral resources of Spirit Lake quadrangle, R. P. Ashley. Previously collected samples will be prepared for thin section, staining, and optical and X-ray petrography. Field data collected in 1978-1979 will be compiled. Study of fluid inclusions in vein deposits will begin.

Molybdenum resource appraisal, T. G. Theodore. Project will continue a worldwide appraisal of molybdenum resources by initiating and maintaining a comprehensive inventory. Field studies will be conducted at selected porphyry molybdenum deposits in Alaska, Washington, Idaho, and Nevada.

Wenaha Tucannon Wilderness, Donald A. Swanson. Field mapping and sampling are complete. Maps and reports will be prepared on the geology and geochemistry, and mineral resource potential of the area.

Indian Lands studies, E. B. Eckel. Administrative reports summarizing unpublished and published mineral resources information will be completed for the following Indian Reservations: Yakima, Chehalis, Hoh River, Lower Elwah, Lummi, Makah, Muckleshoot, Nisqually, Nooksack, Ozette, Port Gamble, Port Madison, Puyallup, Quileute, Quinault, Shoalwater, Skokomish, Squaxin, Swinomish, and Tulalip. Joint reports by the Geological Survey and Bureau of Mines will be submitted to the Bureau of Land Management.

ENERGY RESOURCES ACTIVITIES

Tertiary oil basins of the western United States, Thomas D. Fouch. The project will continue to conduct investigations to determine the origin, migration, and accumulation of petroleum in the western United States. Surface exposures of Tertiary beds in the Pacific Northwest coastal ranges of Oregon and Washington will be examined and samples and published data for resource assessment of Oregon and Washington will be compiled.

A stable-isotope study of granites intimately related uranium-thorium deposits, David B. Wenner. Field and laboratory studies to identify stable isotope characteristics that are typical of granites associated with the occurrence of uranium and thorium will continue. Previously collected samples from the Midnite mine in Washington will be studied.

Geochemical study of granites related to uranium deposits in the vicinity of the Midnite mine, Washington, E. Craig Simmons. A detailed geochemical study will be made of the two-mica granites associated with the uranium deposits of the Midnite mine. Petrologic, rare-earth element, and strontium isotopic studies will be conducted on samples collected. Data will be interpreted and a report prepared dealing with the petrogenesis of uranium-rich plutonic rocks and the formation of hydrothermal uranium deposits.

MARINE GEOLOGY ACTIVITIES

Resource assessment, Oregon-Washington continental margin, Parke D. Snavely, Jr. Geologic mapping in the northwesternmost part of Oregon will be compiled for publication. Geologic maps of the Cape Flattery, Clallam Bay, Lake Pleasant, and Ozette Lake 15-minute quadrangles, Washington, will be prepared for open-file release. Detailed field and petrochemical studies within the Crescent Formation in the western part of the Olympic Peninsula, Washington, to unravel the magmatic history of these lower Eocene oceanic basalts will be conducted.

Marine geology, Frederic H. Nichols. Field and laboratory work on a long-term study of Puget Sound benthos will be completed, and a manuscript on the long-term patterns in the structure of the benthic community will be prepared for publication.

Coastal sedimentology, Ralph E. Hunter. The project will conduct studies of estuaries, beaches, and inner continental shelves in Willapa Bay, Washington. Project will continue to deploy instruments to measure currents, waves, and profile changes in surf zones during storms, and to collect cores 2 to 6 meters long from various modern coastal environments. Even longer cores will be collected this field season from Pleistocene estuarine deposits around Willapa Bay, Washington. Other studies will deal with bedforms, internal sedimentary structures, heavy minerals, and ancient shallow marine sandstone.

Continental margin petroleum resources framework, T. H. McCulloh. Refraction data will continue to be acquired from the Puget Sound, and area and gravity traverses will be completed in the northern section. Data collected will be analyzed and density-geology modeling studies pertaining to Seattle gravity minimum and its geologic history and seismicity will also take place.

Remote deep-water sensing vehicle, William R. Normark. Project will continue work on development and design of deep-water geophysical surveying systems. Final maps resulting from previous investigations in the East Pacific Rise area near 21 degrees north latitude will be prepared and submitted for publication. A new program will be initiated to study deep-sea mineralization and hydrothermal activity of the Juan de Fuca spreading center off the coasts of Oregon and Washington. A short cruise is planned for the summer of 1980 to select areas for more detailed study.

Marine organic geochemistry, Keith A. Kvenvolden. Preliminary investigations of the environmental organic geochemistry of Willapa Bay and Grays Harbor will be completed.

Metallic deposits in oceanic crust, Randolph A. Koski. The mapping program which centers on massive sulfide deposits in ophiolitic terrane in the northern Klamath Mountains of Oregon and California will continue. Other massive sulfide deposits formed in submarine environments in the western Cordillera of California, Oregon, Idaho, and Washington will receive reconnaissance study.

ENVIRONMENTAL GEOLOGY ACTIVITIES

Land-sea geologic transects, Oregon and Washington, Parke D. Snavely, Jr. Seismic-reflection records obtained from offshore southern Oregon will be interpreted in order to tie subsurface geology in five deep test wells with coastal onshore surface geology and four deep test wells in the Oregon Coast range. Seismic-reflection profiles obtained from the northern Washington and Vancouver shelf will be interpreted in order to tie offshore tectonic stratigraphic framework with that of the northwestern Olympic Peninsula.

Puget Sound urban studies, Bruce L. Foxworthy. Reports and maps, scale 1:100,000, will be prepared for the Port Townsend quadrangle, Washington. These products will pertain to the surficial geology, vulnerability of shorelines to spilled petroleum, coastal erosion-sedimentation processes, geologic factors related to waste disposal, engineering properties of surficial materials, and relative ground stability of the study area. Project will also conduct similar studies on coastal process in the Puget Lowland and the Bellingham and Seattle 1° quadrangles.

Wenatchee 2° quadrangle, Washington, Rowland W. Tabor. Bedrock and surficial mapping will take place in the Skyomish and Snoqualmie 1:100,000-scale quadrangles. The Wenatchee 1:100,000-scale quadrangle will be completed and submitted for formal publication, and the Chelan 1:100,000-scale quadrangle will be released in open file.

Tectonic analysis, Washington, Kenneth F. Fox, Jr. Emphasis will be to delineate the major petrotectonic assemblages and tectonic features of the State of Washington. Compilation of maps at various scales and accompanying explanatory text will continue.

Physical and geologic characteristics of catastrophic rockfall avalanches, Robert D. Brown. Field investigations of selected sites in Alaska, Washington, British Columbia, and Alberta, will be conducted in order to observe the lithology, structural geometry, and the mechanics of failure in these areas. A preliminary map which shows the areas in the western United States that are susceptible to rockfall avalanches with a brief text explaining the geologic basis for evaluating the degree of hazard from such rock slides will be prepared.

Relation of geologic framework to uranium resources in the Sandpoint 2° quadrangle, Fred K. Miller. Geologic mapping, geochemical sampling, and ground scintillometer surveying will take place in the north-central and south-central parts of the Sandpoint 2° quadrangle. Map compilation of previously mapped areas will continue, along with analysis and study of collected data.

Earthquake hazards, Puget Sound region, Washington, Howard D. Gower. Bedrock geologic mapping will be initiated in the Bellingham 1:100,000-scale quadrangle. The following maps will be completed and submitted for review and ultimate publication: seismic-response map of the Seattle South quadrangle; seismotectonic map of the Puget Sound region; bedrock geologic map of the Seattle 1:200,000-scale quadrangle; bedrock geologic map of Port Townsend 1:100,000-scale quadrangle; tectonic map of the eastern section of offshore Juan de Fuca Strait; geologic map of the Clear Lake NW $7\frac{1}{2}$-minute quadrangle; and liquefaction potential map of the Seattle-Bremerton area.

Okanogan 2° quadrangle, Washington, Kenneth F. Fox, Jr. Geologic mapping will be carried out in the Bangs Mountain and Bossburg $7\frac{1}{2}$-minute quadrangles. Geologic maps of the Laurier, Boyds, and Churchill Mountain $7\frac{1}{2}$-minute quadrangles will be prepared for open-file release. A report describing an occurrence of ruby in Ferry County, Washington is also in preparation.

Geochemical paleosalinity criteria for selected glacial sediments in the northern Puget Lowland, Washington, David R. Pevear. Collecting of samples from detailed measured sections will continue. Reports dealing with the use of boron and sodium as paleosalinity indicators for Quaternary sediments, clay mineralogy of late Pleistocene sediments in north-central Puget Lowland, Washington, and textural and heavy-mineral data for Wisconsinan sediments in north-central Puget Lowland are in preparation.

RARE II Monte Cristo-Baring, Rowland W. Tabor. Remaining 63.2 square kilometers of

the study area will be mapped and sampled. Project will then be in the report-writing stage and geological, geochemical, and geophysical maps and reports will be prepared in order to determine the mineral resource potential of the area.

Volcanic hazards, Dwight R. Crandell. Original plans were to continue the study of volcanic hazards in the States of Washington, Oregon, California, and Hawaii and the completion of reports dealing with previous investigations. However, in view of the recent volcanic activity of Mount St. Helens, Washington, a considerable amount of time will be spent monitoring, studying, and reporting on that event.

Tephra hazards from Cascade Range volcanoes, Donal R. Mullineaux. The stratigraphy and age of Mount Mazama, Oregon, tephra will continue to be studied. A report on the stratigraphy and age of Mount St. Helens tephras will be completed, if investigations of recent eruptive activity do not interfere.

Re-examination of White River valley train, Mount Rainier, Washington, Robert K. Fahnestock. Field investigations in the study area have been completed and a comprehensive report covering the results of these studies will be prepared. One interesting result of the study was that the Emmons Glacier has advanced approximately 1,500 feet in the last 15 years.

Physical properties and slope stability, Port Townsend quadrangle, Washington, Robert D. Miller. Fieldwork will be completed. Physical property and relative slope-stability maps, scale 1:100,000, will be prepared for the Port Townsend quadrangle and submitted for formal publication.

Ground-failure hazards in the Columbia River valley, Oregon and Washington, Robert L. Schuster and W. H. Hays. Ground reconnaissance studies and mapping of geologic hazards, including landslides, faults, liquefaction, and swelling soils, will be conducted between the Priest Rapids Reservoir and Pasco, Washington. Rocks and soils will be sampled for geotechnical testing.

Branch of Paleontology and Stratigraphy

Neogene mammalian biochronologic techniques, Charles A. Repenning. Although the scope of this project is worldwide, fossil collecting trips will be conducted in the States of Washington and New Mexico.

Middle Tertiary chronostratigraphic framework, Pacific Northwest, Kristin McDougall. Analysis will begin on the biostratigraphy, paleoecology, and chronology of the middle Tertiary of the Pacific Northwest; this will include fieldwork and sample collecting in northwestern and southwestern Washington. The effects of ecology on zonal schemes will be examined, and benthic foraminiferal and larger invertebrate data will be synthesized into an integrated chronology for the middle Tertiary. When defined, the provincial framework will be calibrated utilizing new and available planktic data points in addition to age determinations on the marine sections.

Late Cenozoic diatoms biostratigraphy and paleoceanography of the North Pacific area, John A. Barron. Early Miocene to early Pliocene diatoms obtained from the Deep-Sea Drilling Project site 77B will be studied, cataloged, and photographed. Work on reports regarding late Cenozoic diatom biostratigraphy and paleoceanography of DSDP Leg 63 and late Miocene diatom biostratigraphy of the eastern equatorial Pacific will also be accomplished.

GEOCHEMISTRY AND GEOPHYSICS ACTIVITIES

Genesis of basalt, Thomas L. Wright. Project will continue to formulate and quantify

petrogenetic models for the ocean floor tholeiites, Kilauea, and the Columbia River basalts. Companion studies will emphasize the similarities and differences in (1) source material; (2) depth of melting and differentiation; (3) eruption rates and volumes; and (4) inferred magma storage and conduit complexes.

Regional volcanology, Robert L. Smith. The nature of the relationship between volcanism and geothermal resources will continue to be studied. It is hoped to develop criteria that can be used as guides for geothermal exploration, to develop a better understanding of volcanic activity and geothermal processes, and to construct magma chamber models. Volcanic maps for the States of Oregon, Washington, Idaho, Montana, Wyoming, and Alaska are in preparation.

Columbia River basalt, Donald A. Swanson. Reconnaissance geologic mapping of the Columbia River Basalt Group in northern Oregon and western Idaho, will be largely completed. Mapping in Washington and northern Idaho will be compiled for release in open file. Several reports describing the stratigraphic, structural, and petrologic aspects of the area are planned.

Geologic map of Columbia Plateau, Donald A. Swanson. Geologic mapping is planned for the La Grande, Dalles-Deschutes River, Pilot Rock-Heppner, Willamette Valley, Baker, and Lone Rock areas of Oregon, and the Clearwater embayment and Riggins area of Idaho. Maps at 1:250,000 scale showing the geology of the Columbia River Basalt Group, and the structure contours on the top of the Grande Ronde and Wanapum Basalts, are in preparation.

Goat Rocks Wilderness, Donald A. Swanson. Field mapping and geochemical sampling of the study area will be completed. Reports and maps dealing with the geology and mineral resource potential of the area will be prepared.

Mount Adams NF-052, E. W. Hildreth. The entire 540-square-kilometer study area will be geologically mapped. Aeromagnetic and other geophysical data will be evaluated and the geothermal and mineral potential of the area will be assessed.

Geoelectrical sounding studies, William D. Stanley. Project will continue to estimate the geothermal potential of the Snake River Plain-Yellowstone and Cascades regions and to conduct studies to determine the nature of crustal structures. Magnetotelluric techniques will be used to map conductive structures in the Earth's crust down to depths of 20 km in order to determine the distribution of isotherms. The magnetotelluric method will be refined and instrumentation and data processing advances that are considered to be state-of-the-art will be accomplished.

Geophysics of young volcanic systems, David L. Williams. Plans include the following activities: develop a structural model of the Cascade volcanoes; plan and coordinate a geophysical study of the Cascade Range; and conduct magnetic and gravity studies of the Cascade Range.

Geothermal regional studies, R. W. Simpson. Sampling and analyses of paleomagnetic rocks in southwestern Washington and northwestern Oregon has been completed. Reports will be prepared on the results of these investigations.

Geochronology (Denver), C. W. Naeser. The geochronology of alkalic and granitic rocks from the States of Idaho, Montana, Washington, Connecticut, New Hampshire, Massachusetts, Utah, Wyoming, and Colorado will continue to be studied.

Radiocarbon geochronology and radio carbon chronology directed towards geothermal studies, Stephen W. Robinson. Radiocarbon measurements will be taken in California, Washington, Nevada, Oregon, and Hawaii. These

studies will include a comparison of radiocarbon concentration in river bicarbonates of the pre- and post-nuclear era.

Wilderness geophysical studies, M. Dean Kleinkopf. Gravity surveying in support of Wilderness mineral resource assessment studies will be conducted in Savage Run and Bridger, Wyoming, and Glacier Peak, Washington.

Colville Indian Reservation geophysical studies, Vincent J. Flanigan. Additional gravity, audio-magnetotelluric, and electromagnetic data will be acquired on the Colville Indian Reservation. Final report delineating areas having the highest mineral potential will be prepared.

Wilderness geophysical studies, Calvin K. Moss. Gravity, aeromagnetic, audio-magnetotelluric, and electromagnetic surveys are planned in approximately 12 wilderness areas in the States of Arizona, Colorado, Nevada, New Mexico, Washington, and Missouri. Data acquired will contribute to the mineral resource assessment of those areas.

Remote sensing—geothermal, Kenneth Watson. A computer methodology for registration of aerial images acquired at different times in the durnal cycle will be developed. This technique will be applied to the analysis of multispectral data previously acquired in Hawaii; a report will be prepared documenting the results of this study. Another objective is to digitize linear features mapped from computer-enhanced Lansat images of the Cascade Range from central Washington to northern California. An uncontrolled Landsat mosaic of the region from computer-enhanced images will be prepared.

Gamma-ray spectrometry, Joseph S. Duval. Aerial gamma-ray and magnetic surveys were completed in Medicine Bow Peak and near Douglas, Wyoming; near Metaline Falls, Priest Lake, Mount Spokane, and northwest of Spokane, Washington; near Blanding, Utah; near Lake Roosevelt, Arizona; and near Palm Springs, California. Data acquired from these surveys will be analyzed and interpreted, and reports documenting the results of the studies will be prepared.

Gamma-ray spectrometry for uranium exploration in crystalline terranes, James A. Pitkin. The usefulness of gamma-ray measurements in determining the uranium potential of crystalline terranes will continue to be tested. Field studies will take place in the States of Washington, Idaho, Nevada, and Oregon. Data previously acquired from areas in Washington, Idaho, and California will be computer reduced to apparent concentrations of K, U, and Th, and to ratios of these concentrations. These data will be examined to determine their value in detailing the surface expression of any uranium mineralization; results will serve as a guide for future work in crystalline terranes of the United States.

EARTHQUAKE STUDIES ACTIVITIES

Seismic observatories, Harry S. Whitcomb. Seismic observatories will continue to operate at Newport, Washington; Cayey, Puerto Rico; Agana, Guam; and Adak, Alaska. These observatories provide seismological data that are used to describe the occurrence of earthquakes and their effects on lives and property, and to monitor and record vibrations in the Earth caused by earthquakes and large manmade disturbances. The observatories at Newport, Washington, and Guam also provide input on a 24-hour standby basis to the Tsunami Warning Service operated by the National Oceanic and Atmospheric Administration in Honolulu, Hawaii.

Geothermal tectonic seismic studies, Craig S. Weaver. Seismicity in the Coso Range/Walker Pass region, California, and southern Cascade Range, Washington, will continue to be monitored. A study will be initiated in the

Cascade Range, Washington, to determine if a through-going strike-slip fault exists in the western Cascades and to examine the crust and upper mantle in the transition zone between the Cascade Range and the Puget-Willamette lowland.

Coastal tectonics of the Western United States, Kenneth R. Lajoie. Maps and reports will be prepared dealing with the temperature aspect of Quaternary molluscan faunas of the United States west coast, and a geologic and paleontologic evaluation of amino-acid dating of marine molluscs.

Nuclear Regulatory Commission site seismicity, S. R. Brockman. Review and evaluation of seismological reports submitted to the Nuclear Regulatory Commission (NRC) by electrical power companies seeking permits to construct nuclear power facilities will continue. Sites to be reviewed are Skagit, Washington, and the Washington Public Power Supply System in Benton County, Washington. Recommendations of the U.S. Geological Survey that result from these reviews will be forwarded as administrative reports to the Advisory Committee on Reactor Safeguards and the Atomic Safety Licensing Board.

Outer Continental Shelf (OCS) seismic risk, David M. Perkins. Final seismic-hazard maps for all Atlantic, Pacific, and Alaskan coastal areas will be revised and submitted for open-file release. At this point, this project will be completed.

Crustal strain, James C. Savage. Repeated measurements of spatial and temporal strain accumulation, in order to provide a stable measurement of strain changes and possible precursive strain anomalies, will continue along major faults in California, Alaska, Nevada, Arkansas, New Mexico, Utah, Montana, and Washington. Reports documenting the results of these studies will continue to be prepared.

NEW INFORMATION CIRCULAR RELEASED BY DIVISION

Information Circular 72, Compilation of earthquake hypocenters in western Washington-1978, by Linda L. Noson and Robert S. Crosson, is now available for purchase from the Division of Geology and Earth Resources for fifty cents.

Information Circular 72 is the seventh report in an annual series designed to provide a standardized compilation of earthquake locations, determined by using network data. A multistation telemetered seismograph network has been operated in western Washington on a continuous basis since 1970 by the Geophysics Program, University of Washington. Established stations in western Washington transmit data on the locations, sizes, and properties of earthquakes back to the central facility. This data is compiled for the published reports, which contain machine-plotted yearly summary maps with the epicenter locations and magnitude ranges. A chronological list of earthquakes for 1978 is included.

NEW MINING DISTRICT BULLETIN NOW AVAILABLE FOR PURCHASE

Bulletin 73, Myers Creek and Wauconda mining districts of northeastern Okanogan County, Washington, by Wayne S. Moen, can now be purchased from the Division of Geology and Earth Resources for $4. The report contains 96 pages, 36 figures, and 6 plates.

Myers Creek and Wauconda mining districts of northeastern Okanogan County contain deposits of gold, silver, copper, lead, zinc, and molybdenum. Since 1896, when the area was opened to mineral entry, the deposits have been investigated, but few deposits proved to be large or rich enough to be of economic value.

In the early 1900's, the Bodie gold mine and Phil Sheridan and Zalla M silver mines were the district's leading producers; whereas minor production of gold, silver, copper, and lead came from about 20 other mines. Since 1951, no mine has operated but gold, silver, iron, and copper mineralization in the Myers Creek and Wauconda districts continues to attract attention of mining companies. Studies of these districts indicate that economic deposits of gold and silver remain at several properties, and favorable areas of mineralization are present in parts of the districts.

In light of recent increases in gold and silver prices and increased exploration for these metals, Wayne S. Moen, geologist for the Washington Division of Geology and Earth Resources, has assembled existing data on mineral occurrences of these districts. Bulletin 73 includes mining history, metal production, general geology, and descriptions of mines and prospects.

THESES RECENTLY ADDED TO DIVISION LIBRARY

Copies of the theses listed below are now available for reference:

Bressler, Jason Robert, 1979, Structural geology of China Bend, Stevens County, Washington: Washington State University Master of Science, 105 p.

Garrey, George H., 1902, Glaciation between the Rockies and the Cascades in northwestern Montana, northern Idaho, and Eastern Washington: University of Chicago Master of Science, 93 p.

Helz, Rosalind Tuthill, 1978, The petrogenesis of the Ice Harbor member, Columbia Plateau, Washington—A chemical and experimental study: Pennsylvania State University Doctor of Philosophy, 284 p.

Howell, Jack W., 1977, A field guide to coastal Washington: University of Northern Colorado Doctor of Philosophy, 209 p.

Kolva, David Allen, 1975, Exploratory palynology of a scabland lake, Whitman County, Washington: Washington State University Master of Arts (Anthropology), 50 p.

Marshall, Alan Gould, 1971, An alluvial chronology of the lower Palouse River canyon and its relation to local archaeological sites: Washington State University Master of Arts (Anthropology), 73 p.

McFaul, Michael, 1979, A geomorphic and pedological interpretation of the Mima-mounded prairies, south Puget Lowland, Washington State: University of Wyoming Master of Arts, 77 p.

Pernsteiner, Robert K., 1979, Distribution and behavior of fluorine in uranium-bearing granitic rocks, northeastern Washington: Eastern Washington University Master of Science, 72 p.

Plopper, Christopher Stevens, 1978, Hydraulic sorting and longshore transport of beach sand, Pacific Coast of Washington: Syracuse University Doctor of Philosophy, 185 p.

Ross, Martin Edward, 1978, Stratigraphy, structure, and petrology of Columbia River basalt in a portion of the Grande Ronde River-Blue Mountains area of Oregon and Washington: University of Idaho Doctor of Philosophy, 407 p.

Wu, Yeeming Timothy, 1974, The detailed study of natural remanent magnetization in the Tatoosh granodiorite intrusion of Mount Rainier: University of Pittsburgh Doctor of Philosophy, 185 p.

RECENT U.S. GEOLOGICAL SURVEY OPEN-FILE REPORTS ADDED TO DIVISION LIBRARY

The following open-file reports are now available for inspection in our division library:

Dethier, D. P.; Whetten, J. T., 1980, Preliminary geologic map of the Clear Lake SW quadrangle, Skagit and Snohomish Counties, Washington: U.S. Geological Survey Open-File Report 80-825, 11 p., 2 maps, scale 1:24,000.

Keuler, Ralph F., 1980, Some potential effects of spilled petroleum on shorelines of the Port Townsend quadrangle, central Puget Sound region, Washington: U.S. Geological Survey Open-File Report 80-724, 22 p., 1 plate, scale 1:100,000.

Masters, Charles D., 1980, Status of federal coal resource and reserve data: U.S. Geological Survey Open-File Report 80-250, 27 p. (Presented at a symposium on coal resources/reserves information, September 17 and 18, 1979; sponsored by the Energy Information Administration of the U.S. Department of Energy.)

Perkins, P. C.; Thenhaus, P. C.; Hanson, S. L., Ziony, J. I.; Algermissen, S. T., 1980, Probabilistic estimates of maximum seismic horizontal ground motion on rock in the Pacific Northwest and the adjacent Outer Continental Shelf: U.S. Geological Survey Open-File Report 80-471, 39 p., 7 plates.

Ruppel, Byron D., 1979, A note on the simple Bouguer gravity field in the eastern strait of Juan de Fuca, Washington: U.S. Geological Survey Open-File Report 79-1674, 8 p.

Tabor, R. W.; Frizzell, V. A., Jr.; Whetten, J. T.; Swanson, D. A.; Byerly, G. R.; Booth, D. S.; Hetherington, M. J.; Waitt, R. B., Jr., 1980, Preliminary geologic map of the Chelan 1:100,000 quadrangle, Washington: U.S. Geological Survey Open-File Report 80-841, scale 1:100,000.

U.S. Geological Survey, 1979, Aeromagnetic map of the Cascade Pass area, Washington: U.S. Geological Survey Open-File Report 79-1645, scale 1:62,500.

U.S. Geological Survey, 1980, Aeromagnetic map of the north-central Washington coast; U.S. Geological Survey Open-File Report 80-977, scale 1:125,000.

U.S. Geological Survey, 1980, Aeromagnetic map of offshore northwest Washington: U.S. Geological Survey Open-File Report 80-976, scale 1:125,000.

U.S. Geological Survey, 1980, Aeromagnetic map of the northwest part of the Olympic National Forest, Washington: U.S. Geological Survey Open-File Report 80-950, scale 1:125,000.

U.S. Geological Survey, 1980, Aeromagnetic map of the Grays Harbor County area, Washington: U.S. Geological Survey Open-File Report 80-948, scale 1:125,000.

U.S. Geological Survey, 1980, Preliminary aerial photographic interpreta-

tive map showing features related to the May 18, 1980 eruption of Mount St. Helens, Washington: U.S. Geological Survey Open-File Report 80-925, scale 1:62,500.

Whetten, John T., 1980, Preliminary bedrock geologic map of the Chiwaukum 4 NW quadrangle, Chiwaukum graben, Washington: U.S. Geological Survey Open-File Report 80-456, 7 p., scale 1:24,000.

Whetten, John T., 1980, Preliminary bedrock geologic map of the east half of the Chiwaukum 4 SW quadrangle, Chiwaukum graben, Washington: U.S. Geological Survey Open-File Report 80-616, 6 p., scale 1:24,000.

Whetten, John T., 1980, Preliminary bedrock geologic map of the Chiwaukum 4 SE quadrangle, Chiwaukum graben, Washington: U.S. Geological Survey Open-File Report 80-723, 7 p., scale 1:24,000.

Wright, Thomas L.; Black, Kevin N.; Swanson, Donald A.; O'Hearn, Tim, 1980, Columbia River basalt—1978-1979 sample data and chemical analyses: U.S. Geological Survey Open-File Report 80-921, 109 p.

DIVISION HAS NEW LOCATION

On October 6, the Division of Geology Earth Resources moved to Rowe-Six, 4224 6th Ave., SE., in Lacey. On the back of the cover of this newsletter is a map showing our new location.

If you are traveling south on Interstate 5, take Exit 109 and turn right onto Martin Way. Turn left at the first stop light onto College Way. Go to 6th Ave. and turn right. We are .3 of a mile to the east entrance to Rowe-Six, on 6th Ave., on the right-hand side of the road.

If you are traveling north on Interstate 5, take Exit 108. Turn right onto Sleater-Kinney road. Turn left at the first stop light onto 6th Ave. Our building is about .1 of a mile to the west entrance to Rowe-Six on the left side of the road. You may also take Exit 109.

Our mailing address will remain the same. You may still call us at (206) 753-6183.

USGS REPORTS RECENTLY ADDED TO DIVISION LIBRARY

The two reports listed below are now available for reference in our library:

Frederick, Jan E., 1980, Map showing natural land slopes, Port Townsend quadrangle, Puget Sound region, Washington: U.S. Geological Survey Miscellaneous Investigations Series Map I-1198-A, map and text on one sheet, scale 1:100,000.

Meschter, Daniel Y., 1980, History of the Blewett mining district, Chelan County, Washington—Part 1, The discovery and first phase placer development, 1860-1873: Unpublished Report, 109 p.

U.S. GEOLOGICAL SURVEY 7½-MINUTE TOPOGRAPHIC QUADRANGLES
(Maps received in the division library June 2, 1980)

Name	New edition	Photo revised	Latitude (indicates southeast corner)	Longitude	County
Sagebrush Ridge	1979	--	46°15'00"	119°45'00"	Benton; Yakima
Sequim	1956	1979	48°00'00"	123°00'00"	Clallam

Department of Natural Resources
Division of Geology and Earth Resources
Olympia, WA 98504